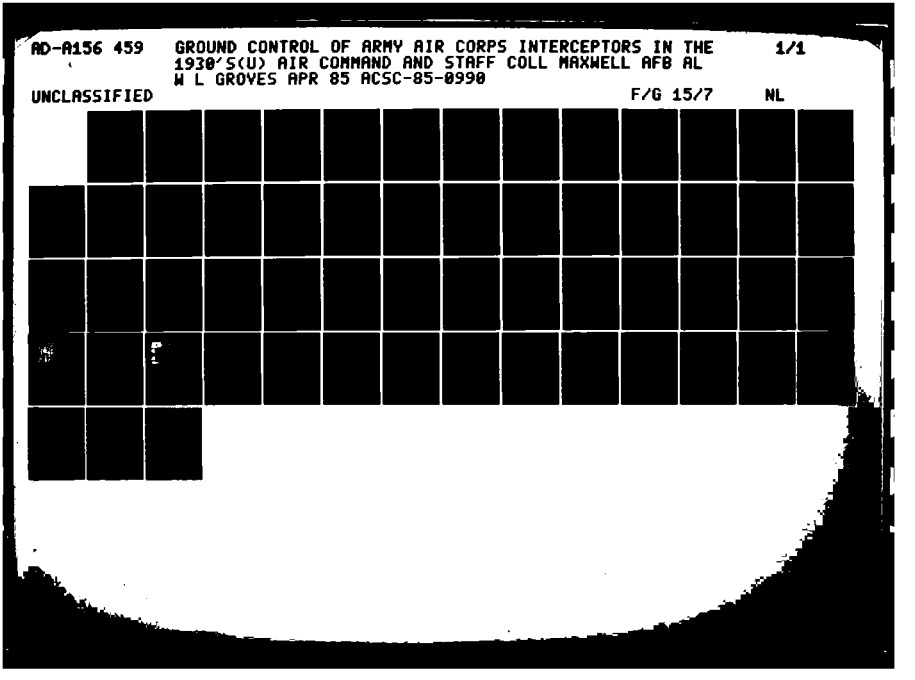
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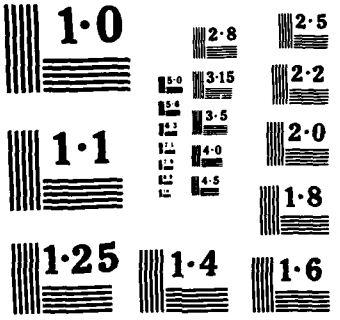

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STUDENT REPORT

GROUND CONTROL OF ARMY AIR CORPS INTERCEPTORS IN THE 1930's

MAJOR WILLIAM L. GROVES 85-0990

"insights into tomorrow"

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AUTHOR(S) MAJOR W. L. GROVES, USMC

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The study traces the evolution of ground control capabilities and techniques used with pursuit aviation during the 1930's. The influence of key individuals is examined, capabilities and limitations of technology discussed, and systems performance in exercises and maneuvers evaluated.

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PREFACE

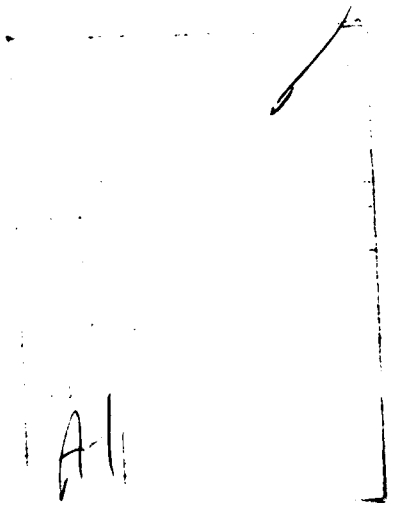
This paper focuses on the evolution of the system for ground direction and control of United States Army Air Corps interceptor (pursuit) aircraft during the 1930's. It is divided into four chapters. Chapter One includes a background perspective of the status of pursuit aviation tactics and the influence of key individuals throughout the period. Chapter Two provides a detailed look at methods, techniques, capabilities, and limitations of the ground control technology of the 1930's. Chapter Three analyzes ground control systems performance during several exercises and maneuvers throughout the period. The Conclusion summarizes the research findings concerning the evolution of pursuit ground control.

Footnotes at the end of each chapter are for use with the reference-by-number citations in the text. The bibliography at the end of this paper lists both references cited and related sources and does not correspond to the reference-by-number citations.

I am very appreciative of the encouragement provided by Mr R. Cargill Hall of the United States Air Force Historical Research Center at Maxwell AFB as well as his guidance and direction in my research. The clerks and staff in the Archives section of the USAF Historical Research Center were extremely helpful in retrieving documents and generally assisting my research efforts. Major Ron Sams, USAF, provided a conscientious sounding board and invaluable editorial assistance. Mrs Jan Hartson was tireless in her dedicated typing efforts.

ABOUT THE AUTHOR

Major William L. Groves graduated from the United States Naval Academy in 1972 and was commissioned in the US Marine Corps. Trained as an air traffic control officer, he was qualified as an Air Traffic Control Facility Watch Officer at MCAS Beaufort, SC. Assigned to a tactical air traffic control unit at Iwakuni, Japan, he helped design and establish the first Ground Controlled Approach procedure at the Marine base camp at Mount Fuji, Japan. As operations officer for another tactical air traffic control unit at Quantico, VA, he participated in operational test and development of the new generation of Marine Corps automated landing system and navigational aids. Returning to Japan as operations officer for an air traffic control squadron, he planned and implemented combined air traffic control exercises with Korean and Philippine armed services. He graduated with honors from the Marine Air Defense Control Officer school in 1982 and became operations officer for Marine Air Control Squadron Six at Cherry Point, NC. Participating in numerous joint and NATO command and control exercises, he was selected in 1983 to establish a remote radar site in Honduras during exercise Ahuas Tara II. Major Groves was selected as the "Marine Air Controller of the Year" in October 1984.



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Chapter One

BACKGROUND PERSPECTIVE

BOMBER SUPERIORITY

The period between World Wars I and II saw great growth and change within the United States Army Air Corps. Expansion and refinement of doctrine and tactics prevailed throughout the service. The improvement of ground control technology for interceptors closely paralleled the development of pursuit aviation. The late 1920's found bomber technology dramatically improved over that of pursuit aviation. (9:5) In the 1920's, proponents of bombardment doctrine such as General Billy Mitchell sought to establish the superiority of bomber aviation. (9:6)

At the Air Corps Tactical School (ACTS) at Langley, Virginia, two instructors, Captain Robert Olds and Lieutenant Kenneth Walker, strongly supported this view. Their position was confirmed in May 1929 during the annual Air Corps maneuvers held that year in Ohio. Major Walter Frank, assistant commandant of ACTS served as an umpire, and, at the close of the maneuvers, he reported:

> There is considerable doubt among the umpires as to the ability of any air organization to stop a well organized, well flown air force attack. . . .

> The difficulty that pursuit had, not only in attacking, but in finding some of the missions that were sent into hostile territory during these maneuvers, would make it clear that a well planned air force attack is going to be successful most of the time. (5:33)

The revision of the ACTS text entitled The Air Force issued in April 1930 boldly stated:

> . . . a defensive formation of bombardment airplanes properly flown can accomplish its mission unsupported by friendly pursuit, when opposed by no more than twice its number of hostile pursuit. . . . An army with an air force strong in bombardment and attack should be able to defeat its opponent. . . . An air force preponderately pursuit, cannot materially affect the ground situation. . . . (5:33)

PURSUIT PIONEERS

It has been said that this doctrine of bomber invincibility interfered with the development of pursuit technology. (9:6) In fact, some important accomplishments in the area of pursuit were made during the late 1920's and early 1930's. Captain Carl "Tooey" Spaatz established an aerial endurance record in the famous 150-hour non-stop "Question Mark" flight in 1929. (2:1) Although the "Question Mark," a Fokker tri-motor, was not a pursuit aircraft, several key pursuit advocates were involved. Captain H. M. Elmendorf was in charge of ground operations and Captain Ira Eaker was on the flight with Spaatz. (6:13) Control measures of the flight were interesting. "Messages to the ground were dropped by the endurance plane, and blackboards on PW-9's were used by the ground crews to communicate with the Fokker. (6:13)

Pursuit pilot Captain Ross Hoyt flew one of the refueler aircraft for Spaatz and later that year set endurance records in pursuit aircraft. His double dawn-to-dusk flight from Washington, DC to San Antonio, Texas, and return with a flying time of under 26 hours demonstrated that "no matter where they may be located, fighting planes of the United States can rendezvous at any point which might be menaced, whether on one coast or on the other, within the space of eighteen hours." (3:1-2) Later, as commander of the 17th Pursuit Squadron in 1932, Hoyt took full advantage of opportunities to conduct joint training with bombardment aircraft during the National Air Races at Cleveland, Ohio. A series of problems involving search, attack, and defense were arranged and flown in the vicinity of Cleveland, and "radio control of the night formation was injected into the problems after a remote transmitter had been rigged through the Municipal Airport." (7:1) Another pursuit pioneer, Major Frank Hunter flew one of a number of P-12 aircraft to Albrook Field, Panama Canal Zone in 1934. This flight represented, at that time, the largest mass flight of US Army planes made to a possession beyond the continental limits of this country. (1:1)

BOMBARDMENT'S SHADOW

Although pursuit aviation did not stand still during the early 1930's, bombardment advocates cast a huge shadow over its development. A major issue during the period was the Air Corps'

campaign against the Navy for the coastal defense mission. Enthusiasm for bombardment aviation strengthened the arguments for the doctrinal role of the air corps. An exercise on the Pacific coast in 1933 provided a maneuver defense against a simulated hostile fleet and accompanying aircraft. In reporting the results of the exercise, General Oscar Westover, the Assistant Chief of Air Corps, declared:

> The modern trend of thought is that high speed and otherwise high performing bombardment aircraft, together with observation aviation of superior speed and range and communications characteristics, will suffice for the adequate air defense of this country. The ability of bombardment aviation to fly in close formation and thus to insure greater defense against air attack . . . warrants the belief that no known agency can frustrate the accomplishment of a bombardment mission. (5:35)

CLAIRE CHENNAULT

As strong as the proponents of bombardment aviation were, a few pursuit activists crusaded for the role of their aircraft. Perhaps the strongest, most outspoken of these during the mid-1930's was Captain Claire Chennault, a pursuit instructor at the newly located ACTS at Maxwell Field, Alabama. A devoted champion of pursuit, Chennault maintained that a bomber raid could be disrupted with fighters if certain conditions were present. These included provision of an effective warning service and intensive training of pursuit pilots in all phases of interception and attack. (9:7) Looking back on the period in his memoirs, General Chennault stated:

> The speed and armament of the Martin B-10 bomber matched 235 miles per hour and five guns against the 225 miles per hour and two guns of the Boeing P-26, then the standard Army and Navy fighter. The neglected field of fighter tactics, together with the total lack of any means for obtaining information about the enemy and tracking his airplanes, made the contest then even more unequal. . . . Biggest problem of modern fighters was intelligence. Without a continuous stream of accurate information keeping the fighters posted on exactly where the high-speed bombers were, attempts at interception were like hunting needles in a limitless haystack. (4:20-21) [emphasis added.]

Chennault did more than theorize about control of pursuit aircraft from the ground. In 1935 he wrote a pamphlet entitled "The Role of Defensive Pursuit" that he used as a text in his course at ACTS. He taught that bombers could be stopped, and used arguments derived from lessons learned in the Air Corps' antiaircraft exercise held in 1933 at Fort Knox, Kentucky. (10:12) Thus Chennault offered a relatively small voice amidst the thunder of support for bombardment aviation during the mid 1930's.

THE GHQ AIR FORCE

In 1935 the General Head Quarters (GHQ) Air Force was created and authorized to go ahead with development of a long-range bomber. Bomber advocates now apparently felt secure enough to snare "defensive" doctrine with pursuit advocates. Almost incidentially, the creation of the GHQ Air Force was an important breakthrough for the development of air defense tactics and procedures. (10:8-9) By 1937, the senior officer

of ACTS, General H. C. Pratt was publicly stating the cause of an integrated antiaircraft defense system that included "antiaircraft artillery with guns, machine guns, searchlights, sound locaters, . . . pursuit aviation with its accessory aircraft reporting service. . . ." (8:18) And, in regard to ground control of pursuit aviation, General Pratt wrote:

> . . . the aircraft reporting service, which tracks incoming airplanes and guides interceptor fighters to them, is fully as important to the antiaircraft defense as the fighter airplanes themselves. It is immediately evident, when an enemy can approach at 20,000 feet at four miles per minute, the aircraft reporting service must operate with tremendous speed and accuracy and must extend a great distance out from the defended point. (8:19)

In regard to pursuit tactics, the general declared:

> The phase of pursuit tactics, that from a viewpoint of time is most certainly paramount, concerns interception. The interceptor unit must approach and see the hostile bomber before air combat can begin. Pursuit tactics, therefore, include the use of the aircraft reporting service to guide the single seater interceptor to its target. (8:19-20)

From the words of General Pratt near the end of the 1930's, an attitude change appears to have occurred within the Air Corps concerning pursuit aviation and its attendant ground control systems. Though several key individuals had supported the role of pursuit aircraft, Chennault was the outspoken advocate of the control system required to make pursuit effective. He pointed toward the need for an adequate warning and vectoring system for pursuit, and his position as

an instructor at ACTS must have provided him an audience with the tactical thinkers of the day. It was a subject that did not go unattended.

FOOTNOTES

Chapter One

1. Biographical Sketch, "Brigadier General Frank O'Driscoll Hunter," K141.2421 in Hunter Papers, USAFHRC.

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3. Biographical Sketch, "Memorandum For Press Relations Branch, G-2," 8 March 1929, K141.2421 in Hoyt Papers, USAFHRC.

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5. Futrell, R. F. Ideas, Concepts, Doctrine: A History of Basic Thinking in the United States Air Force 1907-1964. Air University, Maxwell AFB (1971; revised 1974), AFSHRC Historical Study No. 139.

6. HQ, 7th Bombardment Group AAC, "History," 29 May 1930, 168.65011-7 in Jones collection, USAFHRC.

7. Operational Brief. "2nd Bombardment Group at the National Air Races," from Air Corps News Letter, October 1932, K141.2421 in Hoyt Papers, USAFHRC.

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9. Volan, D. "Air Defense in Theory and Practice 1918-1945," Air Defense Command Historical Study No. 16, K410.041-16 in USAF collection, USAFHRC.

10. -----. "The History of the Ground Observer Corps," Air Defense Command Historical Study No. 36, K410.041-36 in USAF collection, USAFHRC.

Chapter Two

METHODS, TECHNIQUES, CAPABILITIES, AND LIMITATIONS

Academic texts used at the ACTS between 1929 and 1939 taught the principles of pursuit aviation and provide excellent insight into the technique of ground control of pursuit aircraft during the period. The line of instruction provided by the Air Corps' best tactical thinkers shows a progressive expansion of technology and capability in regard to ground control systems. This expansion remained constant in the two basic methods of pursuit employment, daylight and night operations.

AIRBORNE CONTROL

The pursuit texts of the early 1930's (1929-1933) contained almost identical contents concerning control of pursuit aircraft. The basic concept of daylight employment consisted of pursuit group formations made of squadrons in assault, support, and reserve echelons. The group commander, flying in the reserve echelon, controlled the group as it assembled at pre-briefed altitudes and positions over a specified point. Without radios, the group commander's signal to squadron commanders consisted largely of special maneuvers of his

aircraft indicating moves to be taken prior to entering combat. (1:4) Night operations were to be defensive operations taking place over friendly territory in the vicinity of bombardment objectives. Close liaison between ground installations and the pursuit units was acknowledged as required to locate attacking aircraft in flight at night. Vague reference to the use of flares and searchlights was made, but no specific instructions were given for their employment. (3:8) The texts also suggested that the area to be defended be divided into sectors plainly recognizable from the air by prominent landmarks or lights. (2:7) Due to the limited visibility and "insurmountable difficulties of liaison," (3:7), it was deemed impracticable to employ night pursuit formations. (3:7)

GROUND CONTROL

In 1933 little formal systems of ground control apparently existed. General Chennault later remembered the period and the frustrations of pursuit operations:

> The warning system then in vogue was a loose network of spotters who reported vaguely by telephone. Chief function of this net was supposed to be warning civilians to take cover rather than to provide defending fighters with intelligence for interceptors. Normal orders to defensive fighters went something like this: "The enemy bombers reported over Point X at 9 A.M. Take off and destroy them." It would then be 9:15, and X was twenty miles away. When we flew to X and returned after failing to sight any bombers, it was accepted as undeniable proof that fighters could not intercept modern bombers. (9:22)

Probably the single greatest factor in this lack of control system was poor communications technology. Ground communications with pursuit units at the time consisted of smoke from anti-aircraft bursts, colored lights, and panels. The panels were large mechanical devices, sometimes fifty feet square, operating on the same principle as a "Venetian blind." (4:167) The instructors at ACTS realized this deficiency as reflected in a text section on communications:

> The handling of air units in the air and their most effective employment is at present limited by lack of communications. . . . Control during combat is always largely dependent upon a reliable and uninterrupted exchange of intelligence and a rapid dissemination of instructions. . . . The difficulty of control during air combat is occasioned by the existence of the very conditions necessary for the accomplishment of flight. The noise of the engine and propeller coupled with the necessity of continuous movement almost eliminates the possibility of control through the usual auditory means. Lack of adequate communications is probably the greatest stumbling block in the development of air tactics. (4:166)

The ACTS staff also realized the limitations of visual signalling methods of both daylight and night operations:

> Visual signalling is useful but is decidedly limited by the numbers of things the pilot must watch, the light conditions that prevail, the time and space factors incident to operations at high speed in three deminsions, and the small number of visual signals that can be unmistakably transmitted by distinctive movements. (4:166-167)

THE CHENNAULT SOLUTION

A major change in the content of the ACTS texts on pursuit occurred in 1935 when Captain Chennault introduced his

papers on "The Role of Defensive Pursuit" in his classes. Chennault reviewed the background of pursuit development and analyzed the causes for pursuit's failure as an effective weapon. He theorized that "the provision of means for the timely collection and transmission of accurate, continuing information of the hostile force" (8:15) contained the key to pursuit's ability to make interception and to offer effective resistance to a hostile bombardment force. The bulk of his papers described the method for collecting and transmitting this information. His basic theories were:

> 1. That an effective pursuit force can not be maintained airborne at all times
>
> 2. That attacking forces must be intercepted at such distance from the defended point to permit destruction of the attackers before they arrive over their target
>
> 3. That timely information must be provided to pursuit concerning the approach of the hostile force, and
>
> 4. That the information must be transmitted to a central authority, evaluated, and acted upon. Changes in strength, course, altitude, and disposition must be continuously reported as they occur. (8:16-18)

Using current technology, Chennault saw two choices for collecting and disseminating accurate, timely information at frequent intervals: observation aircraft and a ground intelligence net. Aerial observation's advantages were offset by the disadvantages that all information had to be transmitted by radio, that the observation aircraft was vulnerable to hostile aircraft, that continuous surveillance might prove costly, and

that weather conditions might limit success. The ground intelligence net that Chennault envisioned would use a large number of civilian and/or military observers located well distant from the vital area to be defended. Monitoring the approach of hostile aircraft, the observers would report to a central command post via existing civilian telephone or telegraph equipment. Continuously updated observer information could be transmitted to pursuit aircraft via a powerful radio from the command post. The disadvantage of the requirement for large numbers of personnel and equipment was minimal, in Chennault's view. He considered the ability to provide all-weather, continuous day and night operation with freedom from hostile attacks and to use direct telephone communications to be more important. (8:16-19)

Chennault also addressed the problems of command and control of the pursuit force. Concerning evaluation of the information provided by the observers, he saw no special problems. "Final evaluation should occur at the central command post, where competent personnel will be available for this duty. Considerable evaluation will necessarily be done by the pursuit leader in the air." (8:20) [emphasis added] Then, predating one of the cornerstone precepts of most modern command and control systems, he stated:

> Action upon information of the hostile aerial force can be directed only by the central authority, who should have under his command and control the means for collecting and evaluating information, and the

> means for opposing the invasion of the hostile force . . . the central authority should be the commander of the air force responsible for the aircraft defense of the point or area. It is certain . . . that any division of authority in the central command will result in loss of invaluable time and ineffective aerial operations. (8:20)

The details of Chennault's control system were weighted heavily toward a defense system within the United States using existing civilian personnel and communications links. He also recognized the need for a mobile net capable of deployment in a remote tactical situation and recommended the establishment of an "Air Defense Information Group." This group, composed of four squadrons and a headquarters, would operate under direction of the Air Corps Commander. Equipment consisting of "sound locating instruments, course plotting instruments, communications equipment of all types, and other specialized equipment" (8:22) would allow operations in any remote location. He called for the use of this group in all training exercises, especially the annual Air Corps maneuvers. Chennault envisioned the group patterned after similar organizations in Germany and England, a network of observation/listening posts connected to information centers and all information centers connected to area defense headquarters. Adjacent defense areas should have direct connection to each other. (8:22-23)

RADIO IMPROVEMENT

A technical advance during 1935 must be credited with major assistance toward a viable ground control

system. Very High Frequency (VHF) radio circuits

> . . . had been used in the United States as early as 1930 for commercial purposes and found in use in the military services. Since 1935, at which time improvements in tube design permitted the development of good super-hetrodyne receivers for use on this frequency, this service rapidly expanded. With this development came a gradual improvement in performance . . . which increased the range, reduced the signal-to-noise ratio, and provided reliable stand-by features. (7:4)

Obviously the ground control system for pursuit aircraft would not have evolved as it did without a reliable, efficient means of ground-to-air communications.

THE NET

By 1937, the ACTS pursuit texts reflected the influence of Chennault's theories. In general, his plans were incorporated and expanded into an Aircraft Reporting Net. Acknowledging that "there may be many places within striking distance of pursuit that will not be defended by the organization working with the net," ACTS believed the Net to be the "best solution to the problem of defense." (5:69) The Net was organized over the area inside a circle with radius of approximately 125 miles. The ground observer stations, located within this circle at optimum distance of about eight miles apart, reported to a control center by direct wire. Ground observers reported hostile aircraft based on grid coordinates of their sector of observation. Figures 2-1 and 2-2 provide examples of the grid coordinate maps used by both

SIMULATED

AIRCRAFT REPORTING NET

AS USED BY THE AIR CORPS TACTICAL SCHOOL

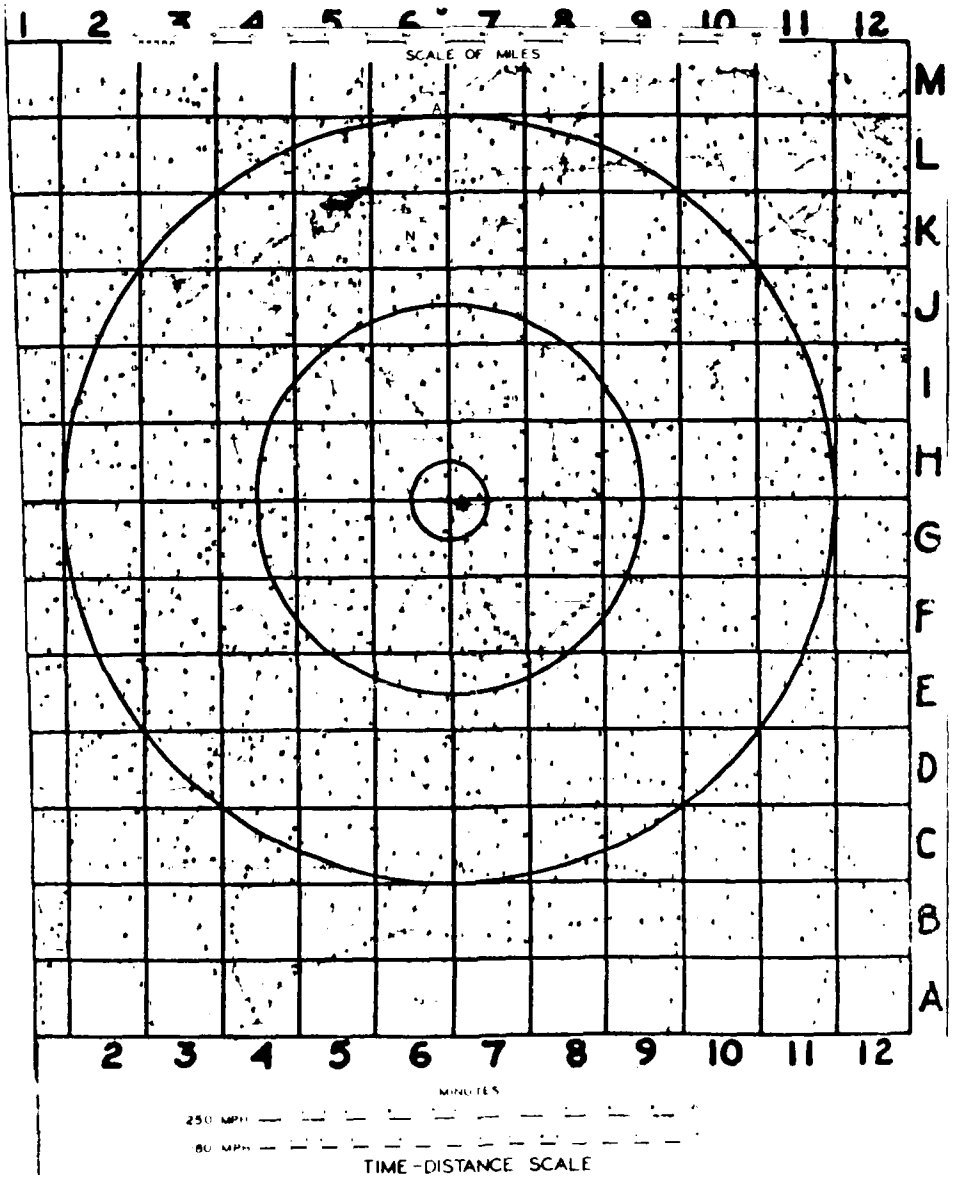
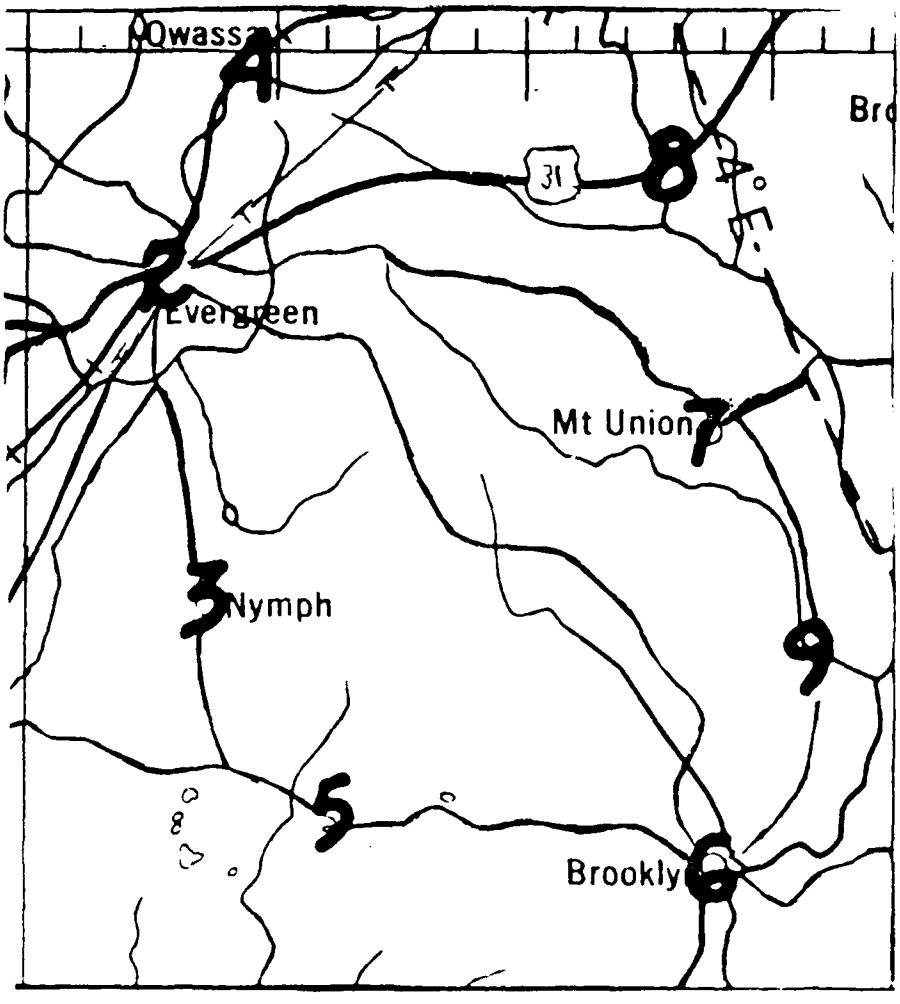


Figure 2-1.

AIRCRAFT REPORTING NET

SQUARE 5-D

SIZE 20 MI. X 20 MI.



NOTE: The above selected square shows in detail:

(1) Distances between stations
(2) Location of stations on highways and railroads along which telephone and telegraph lines actually exist or which can be established by using a minimum of wire.

Figure 2-2.

the ground observers and the control center to locate attackers. As the progress of hostile aircraft was plotted at the control center, the ground commander made decisions concerning use of antiaircraft artillery or pursuit aircraft against hostiles based on tactical considerations as the situation changed. Interceptor aircraft were under the control of the ground commander and were navigated from the ground to intercept the attackers. This required a detailed knowledge on the ground of winds aloft and the pursuit aircraft speeds at different altitudes. Command and control of the pursuit aircraft was retained by the ground commander until he released the formation leader for the actual air combat. Control after the combat returned to the commander on the ground as soon as the formation was reassembled.(5:69-70)

For night pursuit operations, the Aircraft Reporting Net did not change. Although generally unable to see hostile aircraft at night, observers simply stated that aircraft were heard, the time, and the identity of the reporting station. The control center did not attempt to navigate intercepters to hostile aircraft, just to the sector of expected hostile entry. (5:77) The biggest difference at night was the opportunity for pursuit cooperation with searchlights. Searchlights were organized to augment the Reporting Net. Laid out in concentric circles from the defended point, the searchlights could point out attackers with their beams and follow their line of flight to interception with pursuit. Attacking

unseen from lower altitudes, pursuit enjoyed the advantage that the searchlights blinded the attackers as they looked down. (5:77-78) When well coordinated, this form of ground control apparently provided good success for night pursuit operations:

> Searchlights following the enemy into the defended area will extinguish as soon as it comes within range of the next row of lights toward the interior. The following light tends to catch pursuit in the beam and impairs his efficiency in the attack to some degree. The head-on light up to a vertical aids pursuit and makes him invisible to the bombardment. (5:78)

Figure 2-3 illustrates a typical defensive arrangement for searchlight operations in 1937.

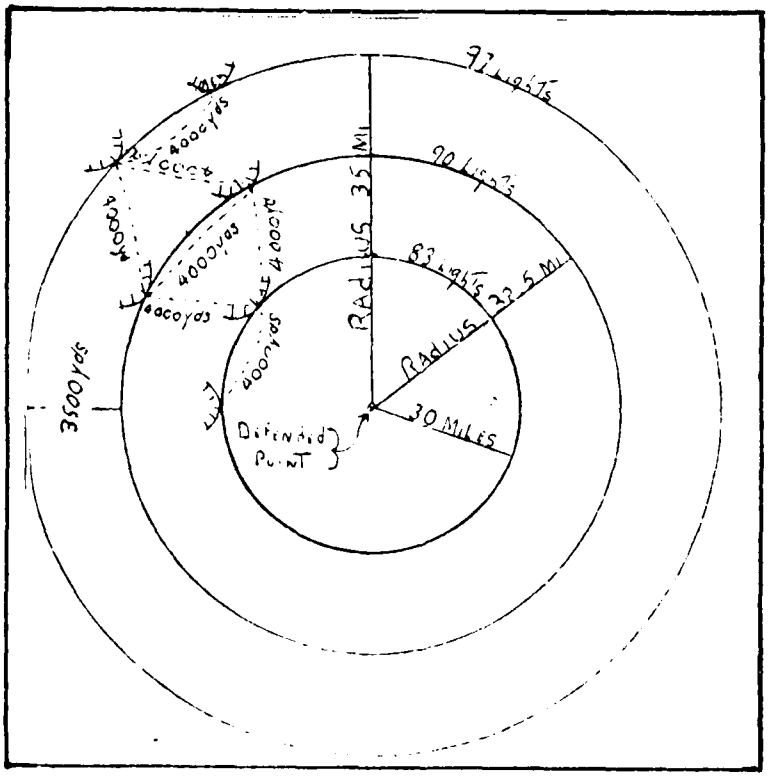


Figure 2-3. ARRANGEMENT OF ANTIAIRCRAFT SEARCHLIGHTS

By 1939 the size of the ACTS pursuit text had grown in volume with considerably more details covering the basic concepts that Chennault had recommended. Now firmly committed to the idea of control of pursuit from the ground, the text advised that:

> All pursuit airplanes should be equipped with radio receivers and those flown by leaders . . . should be equipped with both receivers and transmitters. . . . For interception employment within Aircraft Interception Nets units can be navigated by radio. This will require that interceptor fighters be able to receive and transmit distances at least up to 100 miles. (6:34)

Comments concerning the Aircraft Interception Net in 1939 reflected only minor refinements of the ground control system. More detailed descriptions of the observation station, the plotting room at the control center, and the net's communications procedures were provided, but no really new tactical doctrine was expressed. (6:III) Although still relying heavily on the use of civilian observers, supervision by Army personnel at all critical points in the system was stressed. (6:71)

The disadvantages of a system heavily reliant on radio for ground control communications was described in detail. "The use of radio for this purpose may serve to interfere with the transmission of messages which cannot be sent by other means. The use of radio also serves to decrease the possibilities of secrecy and surprise." (6:76) Standard phraseology, coded routine messages, and grid systems for

navigational codes were advocated. Concern was voiced over delays, however small, in transmission of interception net data and the impact of the efficiency of the plotting crew in predicting the actual position of the enemy at any given instant. (6:81) Also of concern was the ability of observers to estimate "within reasonable limits" (6:82) hostile aircraft altitudes. This ability was believed critical to the successful interception by pursuit.

Concerning night pursuit operations, the ACTS texts of 1939 introduced no different techniques for ground control (searchlight cooperation) than had been previously discussed. The school continued to support Major Warren Maxwell's conclusion that ". . . pursuit aviation will be unable to fulfill the mission at night without the coordinated effort of antiaircraft searchlights." (10:27) Problems did exist, however, in the application of searchlight cooperation. Captain Arthur Nicholson of the Coast Artillery Corps pointed out in a 1939 study that, in conditions of bright moonlight or under light ground haze, the diffusion and reflection of the searchlights reduced the ability of ground crews to distinguish the attacking aircraft. This apparently was not a great problem for the pursuit pilot in the air, except that the searchlight beams were supposed to be pointing out the position of the attackers for him to conduct an intercept. The ground crew had to gain sight of the attackers in order

to point them out. If he already had visual contact with the hostile aircraft, the pursuit pilot was unaffected by moonlight or ground haze. (11:25-26)

After review of the techniques and capabilities of ground control during the 1930's, the evolution of the system becomes more clear. From a system of essentially no ground control in the early 1930's to an elaborate set of detailed procedures existing in 1939, the capability to control pursuit aircraft from the ground, both day and night, made an interesting journey. Clearly, 1935 stands out as a watershed year for advancement of ground control technology. Chennault's paper and instruction on defensive pursuit significantly influenced the tactics taught at ACTS after 1935. But how were they applied, and what were the results?

FOOTNOTES

Chapter Two

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Chapter Three

PERFORMANCE IN EXERCISES AND MANEUVERS

EARLY DISAPPOINTMENTS

The early Air Corps exercises of the 1930's generally produced disappointment for the proponents of pursuit aviation. The Fort Humphreys, Virginia, maneuvers held during September 1931 and the Pacific Coast maneuvers during 1931-1933 showed little promise for the effective use of defensive pursuit aircraft in war. (7:33-35) In neither the ACTS report on the Fort Humphreys maneuvers nor Lieutenant K. N. Walker's study and analysis of that exercise was there any mention of a warning service or intelligence net for controlling pursuit aircraft. (11:1-26) Commenting on the West Coast maneuvers, General Chennault wrote:

> Later "Hap" Arnold, then a lieutenant colonel, conducted Pacific Coast maneuvers on the same problem. He ordered squadrons of Martin B-10's from San Diego in an attack on March Field. Defending fighters at March Field took off according to strict military protocol. There was no vulgar scramble. Flights formed over the field and merged into squadrons. Squadrons then circled until the group commander took off and joined them to lead the formation. By that time the bombers had delivered their attack and departed. Only a few independent fighters, stationed at an outlying refueling field made an interception. They scrambled into the air immediately on receipt of warning without benefit of

> protocol. Arnold concluded from these maneuvers that fighters would be ineffective in wartime. (7:22)

The contrast between these apparent failures of pursuit aviation during the early 1930's and the next major Air Corps exercise is interesting.

FORT KNOX, 1933

In January 1933, Lieutenant Walker wrote from Maxwell Field to Major Carl Spaatz concerning the exercises to be held at Fort Knox, Kentucky in May of that year. Walker strongly recommended the Air Corps "should now take the lead in working up and establishing the principles under which an air intelligence net must be operated." (10:1) Although his proposal may have been based on the political motive of replacing the antiaircraft service in this mission and also in providing jobs for air officers "who will be disqualified physically for flying," (10:2) his comments concerning the value of such a service to pursuit aviation were certainly reflected in the exercise. Using the 1933 exercise as his model in "The Role of Defensive Pursuit," Chennault stated that the exercise plan listed "the use of a distant intelligence net in cooperation with Air Corps units assigned defensive missions," (6:24) as a major exercise objective. Thus, for the first time in a major exercise, the Army Air Corps seriously pursued ground control of pursuit aircraft through "planning the details of the first American aircraft reporting net." (6:26)

Although crude by later standards, the mechanics of the control system established at Fort Knox provide insight into the capabilities during 1933:

> The intelligence net consisted of sixty-nine observation-listening posts with telephone connections and three "radio" posts. It covered an area of approximately sixteen thousand square miles in the form of a 120° angle, with the apex at Knox. . . . The information net was established by the Signal Corps and observation-listening posts were manned by soldiers from the ground branches. These men had very little instruction and experience in identifying aircraft by types and were provided with no instruments for the calculation of altitude or course. The altitude was reported by the indefinite terms, "Low," "High," and "Very High." . . . Communication from observation-listening posts was by telephone to the Pursuit Group operations office. The three "radio" posts communicated directly to the same office by radio. A two-way teletype system relayed observer reports to Defense Headquarters at Fort Knox. (6:26-28)

The results of ground control of pursuit at Fort Knox, whether from Chennault's personal perspective or the official Air Corps reports, have to be viewed as mixed. Writing in 1935, Chennault first pointed out the inadequacies of the system used in the exercise:

> 1. The bands of observation-listening posts were approximately twenty-five miles apart longitudinally. Hostile bombardment and attack could (and did) change course between the bands . . . preventing pursuit from consistently making point interceptions on the enemy's line of flight.
>
> 2. The information net ended at an average distance of about sixty miles from the defended point. Pursuit was forced to make its interception upon information furnished by the inner band of the net. This condition required some unit of pursuit force to be in the vicinity of all the stations on the inner band at the moment the final reports were received. . . .

> 3. It did not furnish pursuit with accurate estimates of the type, numbers, course, and altitude of the hostile force. These inaccuracies forced pursuit to search much greater areas in space than would have been necessary if accurate reports had been furnished. (6:35-36)

Despite these shortfalls in system performance, Chennault maintained that "Its operation enabled pursuit to make a far greater percentage of interceptions than have even before been accomplished in any maneuvers." (6:36) Remembering the exercise years later, the general elaborated on that success a bit more:

> Fighters intercepted and "attacked" the bombers by day and by night, using high, intermediate, and low altitudes on every attempt that was made. Before the maneuver period was half completed, the bomber boys set up a deafening clamor, blaming "unfair conditions," and began limiting the freedom of action of the defending pursuit force. (7:23)

The official after-action report on the Fort Knox exercise compiled at ACTS pointed out essentially the same deficiencies in the ground control system that Chennault observed. (5:1-15) The report acknowledged the results of interceptions by the Pursuit Group, but did not elaborate on the long-term significance of these successes. It did, however, devote significant comment to the method of airdrome control and problems associated with the use of radio communications. A key instrument of control at the airfield was apparently the "Traffic Control Projector" . . .

> . . . an instrument which contains an electric bulb and mirror which can be plugged into an ordinary electric circuit and is controlled by a trigger similar to that of a pistol. This

> instrument projects a narrow localized beam a distance of three or four miles and is so designed that the color of the beam can be changed at the will of the operator. Three colors can be projected . . . red, green, and white. The beam is readily distinguishable and yet other pilots in the vicinity cannot see it. (5:5)

The use of the traffic control projector for ground control of aircraft operating on or around the airport had obvious wartime applications which the ACTS staff readily acknowledged. (5:5-6) On the other hand, tactical radio communications, in the view of the ACTS staff, needed to be cleaned up prior to going to war.

> There is a tendency upon the part of many air unit commanders towards the indiscriminate use of radio communication. Inconsequential messages or last minute instructions which could have been obviated in properly planned missions tend to clutter up the air. . . . Radio silence except in cases of absolute emergency will be the rule rather than the exception during air force operation. Radio should not be employed in tactical operations for the transmitting of information which can be signalled to the various elements of the command in other ways. (5:II-3)

Considering the successful lessons learned during the Fort Knox exercise and the teaching example it provided for Chennault at Maxwell Field, the stage was well set for the next major exercise that occurred at the end of the decade. Since it represented a decade of evolution in ground control technology for pursuit aviation, it is examined in some detail.

FORT BRAGG, 1938

Purpose

The FY-39 Joint Antiaircraft-Air Corps Exercises were held in October 1938 in eastern North Carolina around Fort Bragg. The abundance of planning and after-action material available on the exercise suggests it was of ambitiously large scale for the period. The War Department's stated purpose for the exercise (3:1) included extensive testing of anti-aircraft artillery doctrine and capabilities as well as the following ground-control-related topics:

> (3) To devise methods for coordinating the action between the Air Corps, Antiaircraft Artillery, and the Aircraft Warning Service in the defense of an air base against attack by hostile aviation, including control measures necessary to prevent antiaircraft artillery firing on friendly aircraft operating within the defended area
>
> (4) To test the practicability of organizing an Aircraft Warning Service utilizing non-military personnel as observers, as is contemplated by frontier defense plans
>
> (5) To test the comparative efficiency of military and non-military personnel as aircraft warning observers
>
> (6) To test the ability of ground observers to detect and determine the types of aircraft flying over their respective positions at various times by day and by night. (3:1)

Aircraft Warning Service

The War Department's planning guidance for the exercise directed establishment of an Aircraft Warning Service over an area comprised of 39 rural counties in eastern North Carolina. (2:1) "In perfecting an organization of the

personnel to man the Warning Net it was assumed from the start that a system should be found that could be effectively used in time of war." (2:1) Initial attempts to man the Warning Net with Reserve officers failed due to lack of available North Carolina reservists who were both willing and eligible to return to active duty for the exercise. (2:1-2) "Through the cooperation of local newspapers, the American Legion and other patriotic and civic organizations," (2:1) volunteers were identified by the mayors of towns and cities in the area involved in the exercise. Still lacking enough observers, leaders in the American Legion provided names of District and County Chiefs who filled out the Warning Net organization. These key organizers worked with officers from exercise Defense Headquarters in mapping out the Warning Net grid. The County Chief indicated on the map the name and telephone number of each telephone subscriber at which an observation station was to be located. Also indicated on the map was the exact location of the telephone and the post office address of the individual who was to be the observation post leader for the post in each square. (2:3)

Although there had been insufficient reserve officers to man all the observation posts, the 48 reservists available were used to man 47 Forest Service fire towers. However, the level of civilian interest was so strong that:

> It should be noted that in practically every instance the civilians in the community near a fire tower

> insisted on furnishing observers to assist the Reserve officers. In one or two instances they requested that Reserve officers be not assigned and they furnished all observers. (2:7)

By mid-September 1938 the Warning Service had been established and initial training conducted. Obviously a great deal of preparation went into preparing the Warning Service observers for their jobs. As the observation post leaders were identified, each was furnished

> . . . a bulletin of information acquainting him fully with the purpose of the Joint Antiaircraft-Air Corps Exercise. In addition he was also given very complete notes for observers, prescribing the preparation of "Flash" messages, procedure as to what to do upon observation of an airplane and desirable characteristics of observation stations and observers. (2:4)

Civilian Cooperation

Close examination of the detailed organization of the Aircraft Warning Service for this exercise reveals extensive civilian cooperation with the military. As the district and County organizations were established, the military undertook a "campaign of publicity [illegible] the citizens of eastern North Carolina with [illegible] the . . . exercise and [illegible] therein." (2:4) In addition to the civilian observers, the commercial telephone companies provided [illegible] for the exercise, with coordination and planning [illegible] April 1938. (2:7) Carolina Telephone and Telegraph Company assumed responsibility for "coordinating all the activities of the 15 independent telephone companies in the area," a fact that

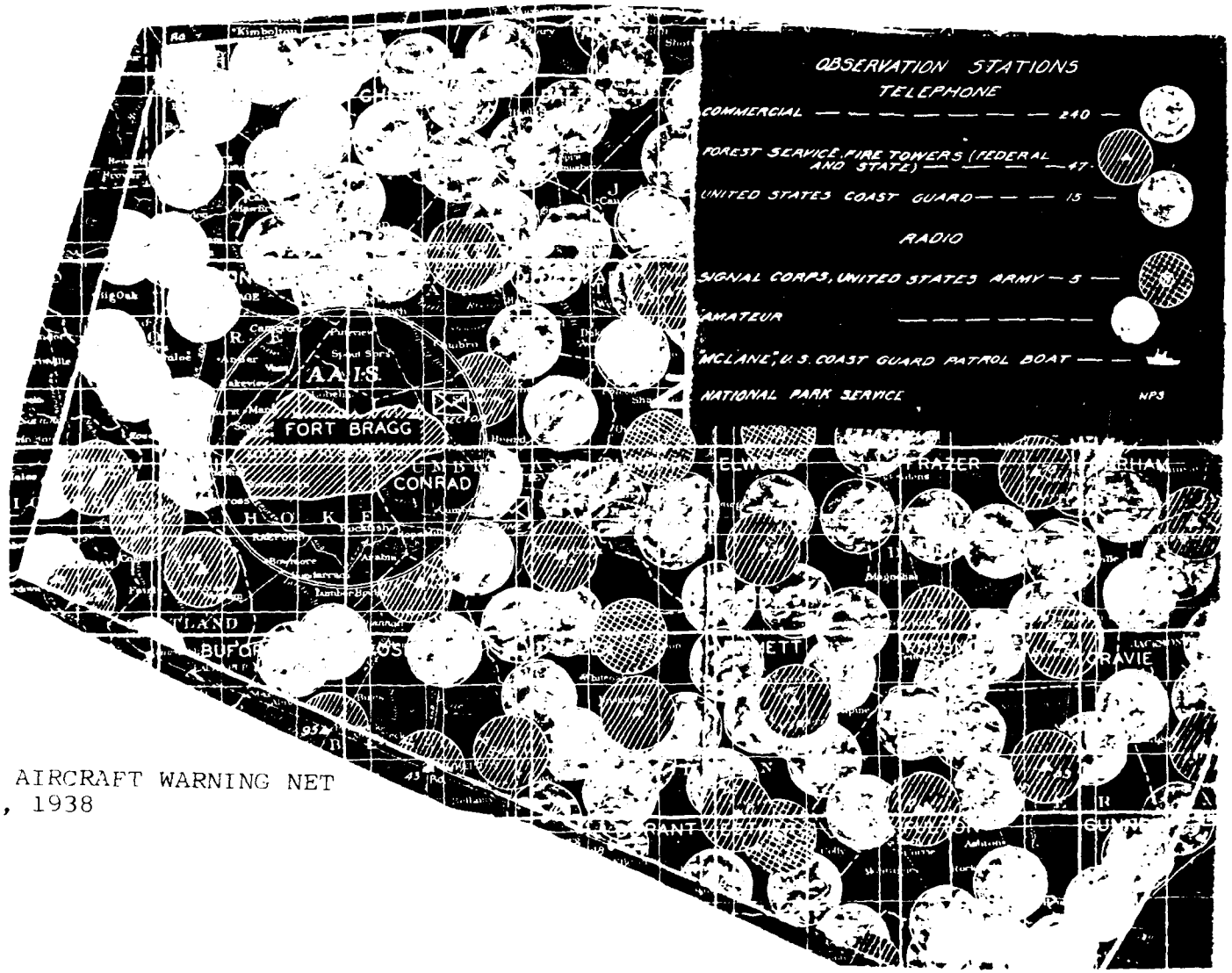
"greatly facilitated organizational problems." (2:7) Additionally, telephone company personnel had to be specially trained in procedures to send the "Flash" messages in minimum time. (2:7)

Figure 3-1 provides a view of the area covered by the Aircraft Warning Net and the locations of observation stations.

The Map Room

An apparent innovation of this exercise, a Map Room provided the ability for observers and members of the press to keep up with the situation. A large scale map of the maneuver area was mounted and . . .

> . . . marked off in code squares . . . showing the location of each observer station by coordinates within the square. The board was wired, each observer station having an individual lamp, all of which were controlled by a series of switches to one side of the board . . . there were installed six loud speakers, one of which was across each of the leased telephone circuits to the Zone Message Center and one was across the microphone circuit of the Pursuit Commander's command radio. Through these loud speakers the "Flash" messages were heard as they were transmitted to the Sector Message Center. At the same time the switchboard operator lighted the lamp of the observer station making the report. Observer lamps were red. Green lamps were used to represent friendly pursuit planes and friendly air fields. Orders alerting pursuit squadrons sending them in the air, and for interception were heard through the Pursuit Commander's speaker and green lights flashed to represent the action contemplated as a result of his commands. At actual interception the green light was switched from one direct circuit to a circuit from a ringing machine which caused the light to blink rapidly and so indicate the enemy planes had been intercepted.
>
> Adjacent to this large map board was another map board upon which was pictured a schematic layout



PORTION OF AIRCRAFT WARNING NET
FORT BRAGG, 1938

Figure 3-1.

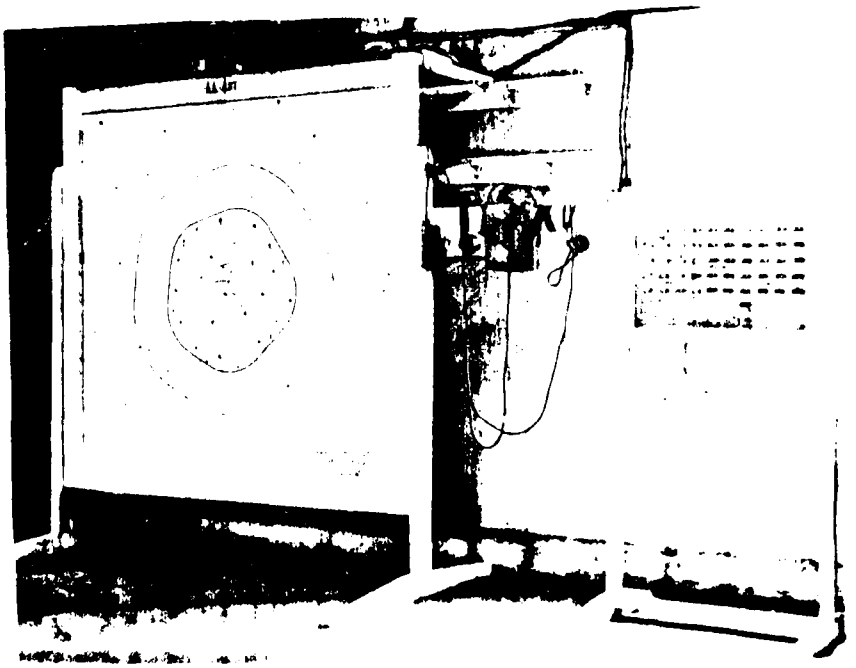
> of the antiaircraft defense, consisting of the bomb release line, the Antiaircraft Intelligence Service observers, searchlight positions, gun positions, and machine gun positions. . . . Through a speaker on a direct circuit from the Brigade Command Post on Gaddys Mountain could be heard the orders as issued from that point putting lights, guns, and machine guns in action. As each element was ordered in action its corresponding light on the board was lighted. (2:7)

Results

In his after-action report, the commander of the Aircraft Warning Service was proud of the accomplishments of his civilian/military force. Looking at the statistics of the organization's structure, it is easy to understand his pride:

> The Aircraft Warning Net covered an area of about 23,000 square miles; the population of which is approximately 1,000,000. This area had the following observation station coverage:
>
> | | |
> |---|---|
> | Civilian Observers Posts | 240 |
> | Federal & State Fire Tower OP's | 47 |
> | US Coast Guard OP's | 15 |
> | Amateur Radio Station OP's | 21 |
> | Army Radio Station OP's | 5 |
> | Coast Guard Cutter | 1 |
> | | 329 |
>
> These civilian observation posts were manned by an average of about 6 observers. Approximately 1800 individuals were employed during the week Oct 10-15. . . . Full and complete cooperation was had at all times. . . . It is estimated that of the 240 Observation Post Leaders 25 were women, and a total of approximately 150 were on duty as observers. There were several observation posts completely manned by negroes. Many of these same 1800 observers manned their stations day in and day out without having an opportunity to see or hear a "Black" airplane. The fact that they were up often in the early morning hours presents a picture of real devotion to a cause and indicates a very high morale. (2:9)

AIRCRAFT WARNING NET MAP BOARD
(Including portion of switchboard
for its operation)



ANTIAIRCRAFT ARTILLERY DEFENSE MAP BOARD
(Including switchboard for its operation)

And, as to the effectiveness of his detection system, the Warning System commander wrote:

> As far as can be determined not a single flight of "Black" airplanes passed over the Warning Net Area without their location being reported to Defense Headquarters with sufficient precision to enable a track of their approach being determined and interception by pursuit aviation. This efficiency on the part of the civilian observers is all the more remarkable when it is realized that at times "Black" bombing planes were flying at altitudes of 24,000 feet and above. (2:9)

Pursuit Commander's Viewpoint

The Pursuit Commander both praised the warning system and pointed out areas of needed improvement in his after-action report. Acknowledging detection performance, he stated:

> The Aircraft Warning Net functioned much better than expected. Airplanes were heard at altitudes of at least 22,000 feet and tracked accurately enough to make interceptions. Messages from the observers reached the plotting section on an average of from two to three minutes from the time airplanes were seen or heard. Bombardment tactics of approaching by single airplanes made the problem most difficult for the Net. (1:8)

Defense Commander's Report

The report of the Defense (Blue Force) commander agreed with the Pursuit commander's findings and made some important additional observations:

> . . . The Exercise afforded an exceptional opportunity for devising methods for coordinating the action of the Pursuit Aviation, Antiaircraft Artillery and the Aircraft Warning Service in the defense of a base airdrome or similar important objective against attack by hostile aviation. . . .
>
> The exercise has shown definitely that both Pursuit Aviation and Antiaircraft Artillery have important roles in antiaircraft defense, that each supplements

> the other, and that joint training is necessary in order to insure the most effective use of both in war. . . .
>
> It has shown that an effective Aircraft Warning Net is necessary to enable Pursuit to make interception in the daytime, and that, at night, pursuit cannot attack effectively without searchlight illumination. (3:15)

The defense commander also made important observations concerning command relationships and command post locations:

> It is desirable . . . that the Pursuit Commander have his command post at the Defense Commander's command post, since this enables both to follow the development of the situations on the same map and renders it possible for a decision to be made and understood without the delay that would be involved in a transmission of orders by telephone or otherwise between separated command posts. The experience of this Exercise demonstrated the desirability of a common command post for the Defense Commander and the Pursuit Commander, both for the reason above indicated and in order to simplify the teletype and telephone communication setup and to expedite the receipt, by the Pursuit Commander, of messages received from the Aircraft Warning Service. (3:18)

War Department's Findings

In a letter to ACTS in 1939, the War Department expressed its views on the exercise and requested comments. General conclusions reached in Washington relating to control of pursuit aviation included:

> a. The establishment of an efficient Aircraft Warning Service is practicable . . .
>
> d. An efficient Aircraft Warning Service is essential to the effective employment of defending pursuit aviation . . .
>
> f. Coordination of pursuit and antiaircraft artillery activities during daylight is practicable. The

> problem of such coordination during darkness has not been solved. (12:2)

Additionally, in listing major equipment deficiencies currently existing, the War Department placed at the top of its list an effective sound locating instrument for use against high-altitude bombardment attacks. (12:2)

The School Solution

After studying the after-action reports from the Fort Bragg exercise, the staff at ACTS prepared a paper for "the consideration of the members of the committee required to recommend changes in the teachings of the school." (4:1) Concerning pursuit aviation, the authors found:

> The daylight operations of the pursuit forces at Fort Bragg merely confirmed the doctrines and tactics now being taught at this school. . . . The employment of pursuit in conjunction with the Aircraft Interception Net as taught at this school had never been attempted by the pursuit groups. . . . The net when it went into operation was surprisingly efficient. (4:6-1)

And, although Maxwell Field was apparently well versed in current procedures,

> . . . one new and interesting feature was brought out in this exercise. It was discovered that for about 45 minutes before daylight on the ground, and for the same period after dark, that high flying airplanes above 18,000 feet were in broad daylight and due to this fact could not be distinguished by ground observers because they could not be illuminated by searchlight beams directed upon them. . . . (4:6-2)

The "bottomline," however, from the ACTS viewpoint was:

> The school theory of a coordinated defense, which includes pursuit, antiaircraft artillery, the

interception net, and the passive defenses was proved sound. (4:6-3)

Study of the Air Corps exercises and maneuvers conducted during the 1930's reveals the same evolutionary flow of accomplishments as described in Chapter Two. Although this has by no means been a description of all the exercises conducted between 1930 and 1939, it points out key examples that apply to ground control of pursuit aviation. From the humble beginnings at Fort Humphreys to the complex, integrated command and control system at Fort Bragg, the effectiveness of pursuit aviation developed in direct proportion to its control system. The decade ended prior to the introduction of radar in field units and the establishment of the Air Defense Command. (9:27-28) Nonetheless, the 1930's saw the Army Air Corps carry the concept of ground control of pursuit aviation through significant technical refinements, which resulted in a pursuit force of enhanced capabilities standing ready to defend the country.

FOOTNOTES

Chapter Three

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CONCLUSION

This paper has traced the evolution of ground control techniques of US Army Air Corps pursuit aviation during the 1930's. This evolution closely paralleled the developing status and operational acceptance of pursuit itself. Although overshadowed by the importance of bombardment in the early years, pursuit's effectiveness and acceptance within the Air Corps made steady progress throughout the decade. By the time the GHQ Air Force was well established in the mid-1930's, ground control techniques had evolved to a respectable level of combat capability.

Several key individuals influenced the development of pursuit aviation during this period from within the Air Corps. Spaatz, Elmendorf, Hunter, and Hoyt were pursuit pioneers whose contributions were important to their cause. None of these, however, provided significant direction in the area of ground control technology when compared with the contributions of Claire Chennault. Blending his observations of English and German control systems with his own interpretation of requirements, Chennault proposed a model system that could make pursuit combat effective. He was quick to point out failures in early exercise attempts at ground

control, and he provided workable solutions to the complex problems of interception by pursuit aircraft. His belief in the requirement to provide pursuit with timely intelligence about enemy positions and the need for control from a central, informed center was essential to the success of pursuit in combat conditions.

Chennault's teachings at the Air Corps Tactical School are heavily reflected in the pursuit texts of the last half of the decade. His basic model of ground observers working in an aircraft warning net expanded by the end of the decade to embrace substantial ground control doctrine. The techniques of daylight and night pursuit operations taught at Maxwell Field in the late 1930's were obviously based on Chennault's proposals and supported by operational successes.

The exercises and maneuvers held throughout the period reflected the evolution of ground control techniques and their acceptance. The early Air Corps exercises and West Coast maneuvers showed little promise for pursuit employment. Subsequent development of higher performance pursuit aircraft, better radio communications equipment, and effective ground control techniques led to surprising exercise successes. The Fort Bragg exercises in 1938 demonstrated that pursuit aviation could be controlled as an effective day or night defense against modern bomber attack. The level of

complex details used to establish the integrated ground control system for that exercise must be viewed as direct descendants of the ideas presented by Chennault in 1935.

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